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ABSTRACT

The concept of a collaborative math and science project grew out of the need expressed by Cleveland State University (Ohio) engineering faculty and junior and senior high school teachers. These groups sought to provide students with connections to "real world" situations that they will face as they transition into the workplace of the future. The underlying assumptions of the collaboration are that secondary teachers' understanding of engineering concepts will be enhanced by engaging in engineering problem solving and that the teachers will then incorporate lessons learned from the experiences into their classroom teaching. The goals for the project were to: (1) improve the quality of instruction provided to students; (2) better prepare in-service teachers; (3) increase understanding of educational barriers to curricular change; (4) facilitate the exchange of information; and (5) foster the mutual respect between secondary school teachers and college/university faculty. Project activities included awareness sessions; a model curriculum workshop; a summer industry experience for teachers with faculty in which curriculum materials were developed; a follow-up team teaching experience for teacher/faculty teams; and development of a monograph describing the project. This paper discusses the awareness sessions, instructional workshops, and summer industry work experiences. Ideas for the project future are also outlined. (AEF)

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The Math, Science, & Manufacturing Collaborative

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TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

The Math, Science, & Manufacturing Collaborative

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The concept of a collaborative math and science project grew out of the needs expressed by university engineering faculty and junior and senior high school teachers. Cleveland State University (CSU) engineering faculty have faced declining enrollments in recent years and local teachers have expressed a concern that secondary students do not perceive math or science to be relevant to their career opportunities. As such, these groups sought to provide students with connections to "real world" situations that the students will face as they transition into the workplace of the future.

The driving force behind the math and science collaborative was the Advanced Manufacturing Center (AMC) located on the campus of Cleveland State University. AMC is an affiliate of the Cleveland Advanced Manufacturing Program (CAMP), an organization that addresses difficult engineering and manufacturing problems encountered by Northeast Ohio industries. From 1995 through 1997, the AMC conducted projects with over 70 regional manufacturing companies to improve manufacturing competitiveness. These projects provided hands-on learning experiences to over 90 undergraduate and graduate students. When compared with traditional students, the AMC engineers contend that students with hands-on experience gain a better understanding of engineering concepts. The underlying assumptions of the collaborative are that secondary teachers' understanding of engineering concepts will be enhanced by engaging in engineering problem solving and that the teachers will then incorporate lessons learned from the engineering experiences into their classroom teaching.

Other partners in the collaborative included the Colleges of Education and Engineering at Cleveland State University. The AMC and the CSU College of Education (COE) have collaborated on a variety of projects related to hands-on manufacturing education with Cleveland area high schools for several years.

The goals for the collaborative project were (a) to improve the quality of instruction provided to students, (b) to better prepare in-service teachers, (c) to increase understanding of educational barriers to curricular change, (d) to facilitate the exchange of information, and (e) to foster mutual respect among secondary school teachers and college/university faculty.

Project activities included awareness sessions, a model curriculum workshop, a summer industry experience for teachers with faculty in which curriculum materials were developed, a follow-up team teaching experience for teacher/faculty teams, and development of a monograph describing the project. Three areas of particular interest revolve around the inception of the project, the awareness sessions, the instructional support workshops, and the industry work experiences.

Awareness Sessions

Project staff spent March to June 1996 conducting awareness sessions with groups of teachers in the Westlake City School District, and representatives of other local school districts. The awareness sessions served as the first step in recruiting participants for the project. A schedule of one-hour awareness sessions were conducted and facilitated at a variety of sites by representatives of the collaborative partners. An overview of the project and the goals were presented to prospective participants. A reaction questionnaire distributed to teacher participants was used to evaluate the outcomes of the awareness sessions. Open ended questions such as; "From a teacher's point of view, if I were organizing a program like this one, I would: (be creative)" were included as well as multiple choice questions related to the utility of the collaborative for developing curricular materials. The questionnaires provided the project staff with information to determine reasons for teacher interest in the program and barriers to attending the program so that this information might be incorporated in planning for future efforts.

Participants identified five major reasons for program interest:

1. The project is connected to "Real Life";
2. Students will "turn on" when provided with unique experiences;
3. Teachers will be able to give students marketable skills;
4. Teachers will be able to show students the relevance of math and science to the real world and careers;
5. Projects and "hands-on" activities are important in preparing students with marketable skills.

In order to define the concerns, goals and activities that met the common educational concerns of the different

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partners, five focus group meetings convened among the AMC, COE, Greater Cleveland Educational Development Center, Westlake City and Elyria School districts (teachers and administrators). The focus group participants identified several common educational concerns:

- fewer students interested in pursuing math, science, and engineering careers,
- the need to address multiple intelligence and various learning styles,
- the need to adopt methods that teach the conceptual requirements of the Ohio model curriculum,
- the need to increase the tools available to teachers that enhance teaching in an applied method,
- the need to supplement teacher's expertise of technology skills required in a modern workplace, and
- the need to develop new curriculum and methods to prepare pre-service and in-service teachers.

The awareness groups also defined several needs of the teachers. Primary among these needs was experience working in business and industry. This leads to difficulty in redesigning curriculum to appropriately reflect "real world" applications. Some also reported a lack of awareness of the broad scope of career opportunities that are available to students who wish to pursue science, mathematics, and engineering degrees. Another need identified by some teachers was a better understanding of how to incorporate teaching methods that address diverse learning styles and multiple intelligence. Most teacher participants understand these concepts but indicated that they were uncomfortable developing appropriate classroom activities to address them. University faculty indicated that they are frequently critical of the elementary and secondary educational systems because students increasingly come to higher education unprepared for college level work. However, the same faculty admitted that they knew little about the problems that teachers encounter especially in the areas of secondary math and science instruction. The different participants agreed that an ongoing forum to foster mutual understanding among faculty and teachers was needed.

Instructional Workshops

One component of the project was planned to provide participant teachers with a series of instructional workshops prior to a "Summer Industry Experience". Workshops addressed the following topics: secondary science and mathematics standards, cooperative learning, simulations, problem-centered learning, and inquiry-based learning. Participating teachers completed a questionnaire at the end of a three-day workshop. The information collected from the questionnaires was used to help the project staff evaluate the workshop effectiveness and to incorporate modifications to the project.

Seventy-two percent (23 out of 32) of the teachers completed the post workshop questionnaires. The questionnaires provided opportunities for the teachers to respond to issues regarding the usefulness of the instruction, the quality of the instructional materials presented, familiarity with the methods employed and the quality of the instructors. In general, the teachers responded favorably to the instructional workshops. The information collected from the questionnaires indicates that most of the teachers were responsive to the materials covered in the workshops. However, answers to the open ended questions suggested that the teachers were confused about project direction early on in the process. Statements such as, "lack of direction about individual projects- no idea how to select a project", "I still feel lost. I don't think enough time was spent discussing our individual projects", and " the product is still not clear to me, hopefully this will be clarified as time goes on", indicate that the teachers, though enthused about the project were not clear about the direction. One possibility for the lack of comfort may have been related to the order of activities in the instructional workshops. The workshop curriculum activities were conducted prior to teacher discussion of possible projects with the engineering faculty. As such, the teachers were unclear as to what their responsibilities would be once they began the third phase, the summer engineering experience. Most activities in the instructional workshops were highly structured to cover the different curricular topics. The result was that few opportunities were provided for teachers to discuss the actual summer engineering activities with the faculty. Additionally, faculty attendance became increasingly erratic as the workshops progressed, reducing further the opportunity for interaction between the teachers and the engineering faculty. The result was that decisions regarding the selection of a summer engineering internship were postponed until the last minute. In general, a teacher's decision to work on one project versus another was not well informed.

In summary, some teachers indicated the workshops provided a good review and they were open to finding out more about the curriculum that they had committed to produce for the project. However by the close of the instructional workshops the teachers appeared somewhat confused about the next step - the summer industry work experience.

Summer Industry Work Experience

The teacher and faculty participants collaborated on 15 different engineering projects during the summer. Typical group size consisted of 1 engineer paired with 2 - 3 teachers. The purpose of the work experience was to provide the teachers with a context for understanding how engineers solve problems so that the teachers could then use this experience to develop curricular materials reflecting similar types of problem solving. Problem solving issues embedded in the projects revolved around Computer Science (hardware and software), Industrial Engineering, Mechanical Engineering, Chemical Engineering, and Civil Engineering.

All of the projects required working with a variety of software and hardware engineering tools. Most of the teacher participants were unfamiliar with the engineering tools at the outset of the summer work experience. The teachers were required to commit 120 hours on the industry work experience.

Teachers and faculty were asked to give the project staff feedback on their "Summer Industry Work Experience." A questionnaire was mailed to participants in August of 1996. Participants were asked a series of questions related to their work project.

Three major themes surfaced from the teacher surveys of the industry work experience: Project Planning and Preparation, Highlights of the Learning Experience, and New Ideas for the Project's Future.

Project Planning and Preparation

Teachers and faculty alike seemed uncomfortable with the perceived lack of information about the project at the onset and throughout the summer. Several possible issues may have contributed to this lack of comfort.

First, although the engineers had collaborated on industrial projects with manufacturing personnel this was the first opportunity for them to work with secondary teachers. Despite considerable project planning, meetings and revisions not all variables were foreseen. In particular, neither group was clear on how to achieve the goal of integrating the engineering experiences into instruction. In addition, it took time to learn what aspects of the project worked and what aspects did not. A formative report on the summer phase of project was completed after the work experience. Thus, by the time potential revisions were identified, it was too late to implement them into the summer experience.

Second, many of the teacher candidates who had expressed interest during the awareness sessions had already committed to other projects during the summer before notification of funding for the project occurred. Time was passing and the need to recruit teachers was immediate. As such, many of the newly recruited teachers had not attended the awareness sessions and did not fully understand the scope and purpose of the collaboration. Additional time was needed to clarify the purpose of the summer experience to both the engineering faculty and the participant teachers.

Third, the project was unable to hire a coordinator until after funding was secured. As such, much of the initial process of recruitment, interviewing and selecting a coordinator were occurring at a time when information critical to understanding the purpose of the project needed to be disseminated to potential participants. Engineering faculty were recruited by the Project Administrator. Most of the communication between the administrator and the faculty was oral and some of the engineers were not clear about the scope of the project or their role in it. The project brochures provided to teachers outlined the basics aspects of the program but additional detail on specifics was required.

In summary, further explanation and preparation of faculty and teachers was required in the planning phase of the project. Once the summer industry work experience were underway participants were able to work out most of the problems that confronted them but it would have been better if all parties knew what to expect from the other at the outset.

Highlights of the Learning Experience

The three basic components of the learning experience were to provide the teachers with (a) fifteen flexible days to work on complex projects developed by the engineering faculty and AMC staff at the AMC or an industrial site, (b) five flexible days for developing curriculum relevant to the teacher's curricular goals, and (c) five days for advanced training in an area of interest. All three components were implemented and comments by the teachers help explain what worked well and what might be improved.

The "loose structure" of the summer experiences made the program expectations somewhat vague but also provided freedom for the participants to explore and develop areas of personal interest. Many of the participants noted that engineering involves a great deal of problem solving and that these problems are solved cooperatively and that it takes considerable time and creativity to solve problems. Other participants learned that communication plays an important role in engineering. Knowledge of an idea is insufficient if you cannot communicate the idea to others.

One comment by a participant "I learned that teachers can bring industry/manufacturing into the classroom and train students to have skills for the 'real world'." provided support to the original goal of encouraging teacher participants to create curricular materials that reflect the problem solving approach used by engineers.

Ideas for the Project's Future

The teachers, in their questionnaire comments, offered many ideas. Many of these comments revolved around the practical constraints of applying the ideas embedded in the summer work experience in the classroom. Primary among the suggestions was the need to consider how the engineering and manufacturing experiences might be applied to the computers available in the local schools. Computer classes and equipment are required to accomplish specific tasks and both the classes and the equipment should be offered to the teachers prior to the industry work experience, so that the teachers are more adept with the technology before they become involved in a project.

Time or lack of it appeared as an important issue to the teacher participants. Several indicated that providing informal time for teachers to discuss issues such as curriculum development was critical for meaningful integration of activities in the classroom. The teachers also suggested that

the engineering faculty might benefit from opportunities to learn basic principles of teaching and learning.

Conclusion

This report was an informal assessment of the math, science and manufacturing collaborative. It was an attempt to reflect on the experiences of the participants based on their responses to a series of simple questionnaires. Although the preliminary findings are generally favorable it is too early to generalize this experience to other projects.

What is interesting about the questionnaire feedback is that this feedback does not merely state the problem but frequently includes suggestions for how the project might remedy the problem in the future. Based on the questionnaire responses it was clear that many of the teachers had developed a commitment to the project from their summer work experience. Information is currently being collected from the teachers, faculty and project administrators via in depth interviews. The interviews should provide additional information regarding the efficacy of the project.

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